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CLIMATE CHANGE WITH ARTIFICIAL INTELLIGENCE

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ABSTRACT

Since Greta Thunberg made her urgent pleas to government officials all over the world for them to take action against our deteriorating climate conditions that would ruin the future of generations to come, we have witnessed the unravelling of genuine proof, the statistics and data from millions of scientists worldwide warning us about the biological and ecological transformations that will eliminate our natural resources and leave humanity in despair. It is no longer feasible to ignore climate change. The future of saving our environment and promoting reduced damage to our climate could happen better with the advancements offered by artificial intelligence. Artificial Intelligence (henceforth, AI) could potentially enable us to transform our post-industrial revolution ideals of progress and technology to ones that are more fitting to Industry 4.0, where our technologies will actually be used to replace the status quo of manufacturing and producing by using ecofriendly or green technologies. AI holds the key towards this greener future by offering us solutions in the areas of renewable energy and waste management.

KEYWORDS: Climate change, Artificial Intelligence, Machine Learning, eco-friendly, greenhouse gases, environment.

INTRODUCTION

Climate change has become a predominant concern and area of research in the last few years. Discussions about how to change the human-caused destruction of the environment can be altered and ceased have permeated cultural and political circles. NASA defines climate as “the average of meteorological facts which happen in specific regions and which are observable over an extended period of time.” Climates can be determined for specific regions and have been altered significantly since humans first started to mass produce and consume during the first industrial revolution. Usually dependent on seasonal temperature and weather conditions, climate change, however, can take hundreds of years to be physically noticeable and varied.

Artificial Intelligence has a significant role in the way we change our climate and optimize our ecosystems. It was John McCarthy during the late 1940s who envisioned AI and how it would make a change in the world. His definition of artificial intelligence revolves around “the science and engineering of making intelligent machines, especially intelligent computer programs.” Moreover, "at its simplest form, artificial intelligence is a field, which combines computer science and robust datasets, to enable problem-solving.” This also includes machine and deep learning methods that are becoming increasingly correlative with the term AI. They mostly comprise designing algorithms that can enable certain tasks such as the prediction and classification of data. Machine learning (henceforth, ML) “gives computers the ability to learn without explicitly being programmed.” ML revolves around the use of data in all formats such as images, symbols and all formats of text and information. In the case of training AI, data can be used as a training tool. The intent is to train the algorithm to identify types of data enabling it to perform tasks on various datasets. In the case of climate action, AI is the only feasible channel to process such a massive amount of data so that humans can take the necessary steps to halt and change their path towards improving their environmental harm.

Statistical information from global organizations and institutions around climate conditions and change proves that AI will be beneficial in the ways we optimize our climate systems. We may begin with the simple data that tells us that in order “to avoid the extreme consequences accompanying a global temperature increase of 2°C”, we must take action to decrease our greenhouse gas emissions by 45% by 2030. This would have to increase by 100% by the year 2050. Studies have shown that AI could prove to be extremely helpful in tackling these concerns. For climate action to take place “meaningful climate science requires collecting huge amounts of data on many different variables such as temperature and humidity, but working with such massive data sets is challenging.” This is why AI algorithms must be enhanced and optimized so that they can be integrated into many green technologies that can track the weather, animal and human impact on the environment as well as make predictions about our environment-related behaviour.

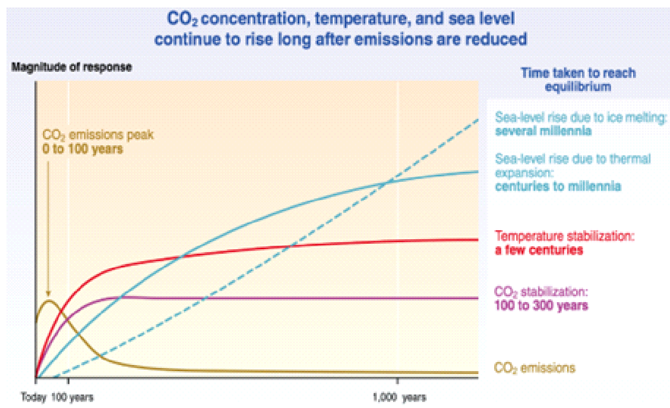

Figure 1: The Rise of Climate Change After Emissions Reduction

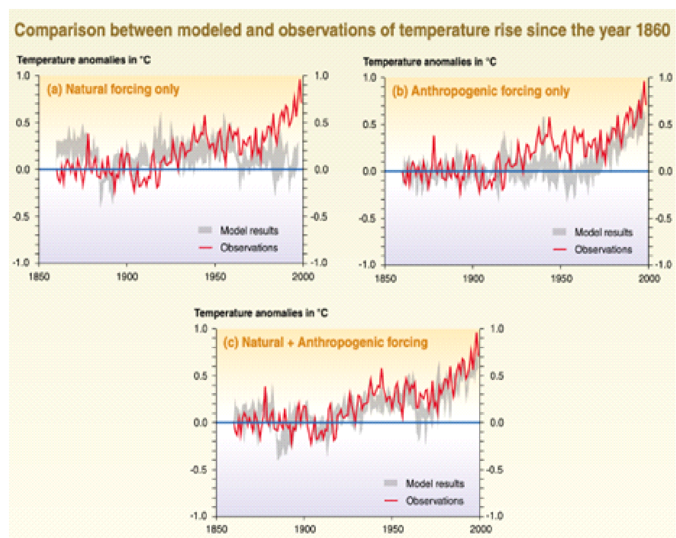

Figure 2: The Change in Global Temperatures from 1860 until the year 2000

Figure 3: Global Warming in 2021- “Human experience of present-day warming. Different shades of pink to purple indicated by the inset histogram show estimated warming for the season that has warmed the most at a given location between the periods 1850–1900 and 2006–2015, during which global average temperatures rose by 0.91°C in this dataset.”

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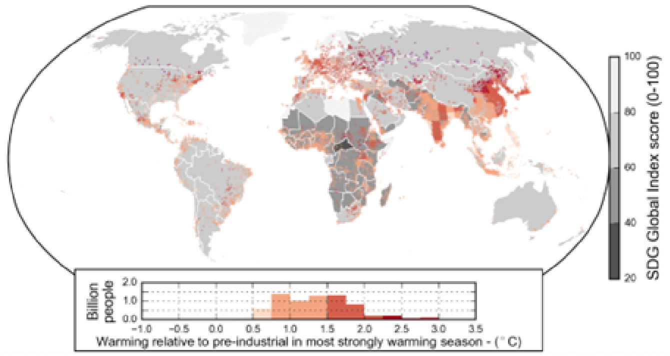

AI today can already be used in various environmental areas such as in oceans and water ecosystems where they can analyze images of reefs to identify coral and identify how climate change impacts them by detailing their changing colours. Moreover, AI can be used in forested areas to measure the levels of CO2, humidity and temperature.

For the greenhouse gas effect, or the heating of the atmosphere from the increased sunlight that is absorbed by the oceans and the earth, AI can be beneficial in the novel energy tracking models such as those used by the IEA (The International Energy Agency). "To have a significant chance of keeping total warming below 2°C, we need to cut global emissions of carbon dioxide and other major Greenhouse Gases (GHG) pollutants by more than 50% by mid-century." Climate and energy are interrelated and Stanford University argues that it is not possible to address one without the other and having "a reliable low-cost energy system is absolutely crucial." The need to stop the use of fossil fuels and increase our actions against climate change are essential otherwise, we could contribute to a 20% loss of our global GDP too in the process.

The burning of fossil fuels creates excess carbon dioxide in the atmosphere, making it a greenhouse gas. But there are other gasses which contribute to climate change such as methane, nitrous oxide, chlorofluorocarbons and carbon tetrachloride. The primary contributors to the production or release into the atmosphere in excess, of these greenhouse gasses are human activity. The best way to move forward is by eliminating the need to burn fossil fuels and our dependence on chemicals, such as in agriculture as fertilizers, or in the dying process in the clothes industry and many manufacturing companies where coal is burned or the dependence on petroleum, such as in oil companies, is continued to be used at the global level.

Artificial Intelligence - Renewable Energy

The best way to move forward to avoid the use of natural resources, such as coal or petroleum, which are non-renewable, is by using renewable resources. However, there are some renewable resources that do not produce clean energy or zero emissions. Moreover, the future of renewable energy is dependent on new technologies that will optimize the natural resources we have that will work in line with environmental awareness to also bring forth the needed management and distribution of systems that will use renewable energy. Jha et al. (2017) explore the multitude of forms of energy from solar to hydro, ocean and bioenergy, among others, to detail the ways single and hybrid forms of AI can enable us to better use these natural resources. The traditional ways of using natural resources have contributed to global climate change. Many countries around the world, such as China which in 2013 was the world's largest consumer of fossil fuels, have adopted renewable energy sources, and some like Costa Rica, have already achieved (or claimed to achieve by 2021) 100% renewable energy goals. The European Union has given guidelines that by 2030 countries should have reached a 27% renewable energy goal. Jha et al. (2017) point that out in the literature focused primarily on the uses of renewable energy in the form of solar and wind energy. AI applications can be used in all these types of renewable energy in terms of "design, optimization, control, distribution, management, and policy." In the case of wind energy, AI, according to Jha et al., is most useful when approached with neural learning approaches for the "prediction of wind speed and wind power", but that research shows statistical and evolutionary learning can also be very beneficial for renewable energy sources. Moreover, they claim that back propagation neural networks are very accurate in the estimation of wind power, but also find that "ANN methods BPNN, RBFNN, and adaptive linear element network (ADALINE)" are also of utility. Jha et al. (2017) explore 30 types of AI for use in the management and regulation of wind energy that can be used for not only wind speed and power prediction but also used to monitor "missing wind data interpolation", "design of wind generation system", "wind turbine fault diagnosis", and "risk optimization in wind energy trading". Such studies reveal that the uses of AI are multitude in the wind energy sector, but can also be applied to climate action in waste management.

Ref. no.	Method/methods	Application	Outcome
[214]	BPNN	Wind power prediction	RMSE 0.0065
[215]	BPNN, RBFNN, and ADALINE	Wind speed prediction	RMSE 1.254 for BPNN
[216]	BPNN	Wind power prediction	MSE 7.6 ×10-3
[217]	Recurrent high order ANN, and NB	Wind power prediction	RMSE 4.2
[218]	BPNN and TPCSV	Wind speed prediction	Correlation 0.95 for BPNN
[219]	BPNN	Wind speed and power prediction	20–40% improved accuracy
[220]	BC, ADALINE, BPNN and RBFNN	Wind speed prediction	RSME 1.5 for BC
[221]	ARMA, NLN and ANN	Wind speed prediction	RMSE 4.9% for NLN
[222]	BPNN, and SES	Wind speed prediction	MAE for BPNN 0.5251
[223]	Fuzzy method	Design of wind generation system	3.5 kW
[224]	ANN, RBFNN, and fuzzy methods	Wind power prediction	Planning 1–48 h ahead
[225]	BPNN and fuzzy methods	Wind speed prediction	RMSE 3.30 for BPNN
[226]	Probabilistic method	Wind power prediction	Reliability (2–4%),
[227]	SVM, BPNN	Wind speed prediction	MSE 0.0078 for BPNN
[228]	ANFIS	Wind power prediction	MAE < 8
[229]	ANFIS	Wind speed prediction	MAPE 3% at 40 m
[230]	ANFIS	Missing wind data interpolation	RMSE 0.230
[231]	ANFIS	Design of wind generation system	Error 0.005
[232]	BPNN+WT	Wind turbine fault diagnosis	Detection of 8 conditions
[233]	PSO+BPNN	Wind power prediction	2.8% improved accuracy
[234]	EMD+FNN	Wind speed prediction	MSE 0.1296
[235]	ANN+MC	Wind speed prediction	Error 94.84
[236]	Hybrid method (Fuzzy-GA)	Wind speed and power prediction	29.7% improved accuracy
[237]	Hybrid method (EEMD-SVM)	Wind speed prediction	MAE 0.12
[238]	Hybrid method (ARIMA-BPNN)	Wind speed prediction	MSE 0.49
[239]	Hybrid method (MM5-ANN)	Wind speed prediction	MAE (1.45–2.2 m/s)
[240]	Hybrid method (WT-SVM-GA)	Wind speed prediction	MAE 0.6169
[241]	Hybrid method (SVR-PSO)	Wind speed prediction	Effective accuracy
[242]	Hybrid method (ACO-PSO)	Wind power prediction	MAPE 3.5%
[243]	Hybrid method (WT-PSO-ANFIS)	Risk optimization in wind energy trading	Profit estimation for risk level (0.0–0.1)

Source: Jha et al. (2017)

Figure 4: 30 AI Applications for Wind Energy

AI for Waste Management

By 2050, the global volume of solid waste will cross 3 billion tons. In order to better manage this amount of waste, AI could potentially be able to help us figure out solutions. We are currently in critical need to improve our waste management systems and "AI has been widely implemented to solve problems related to air pollution, water and wastewater treatment modelling, simulation of soil remediation and groundwater contamination as well as planning of SWM strategies. SWM or Solid Waste Management varies from the management of recycled materials yet the ways AI can be implemented for both systems are similar. In the area of SWM, AI is "extensively used to forecast waste generation patterns, optimize waste collection truck routes, locate waste management facilities, and simulate waste conversion processes, among others". The most prominent way AI can assist in SWM is by prediction. Thus, it is most accurate and efficient for "waste bin level detection, forecasting of waste characteristics, process parameters prediction, process output prediction, vehicle routing, and SWM planning.". The AI types, in terms of algorithms used, are ANNs, "support vector machine (SVM), linear regression (LR), decision trees (DT) and GA (genetic algorithms)".

According to a study by Yetilmezsoy et al. (2011) artificial intelligence for waste management in recycled materials revolves around image recognition and data analysis. This process includes 2D and 3D methods where the AI can see which ones are plastic bottles, but it is not very efficient at distinguishing between types of cardboard packaging. Deep learning algorithms can be trained to recognize waste. Researchers who are studying the use of AI for recycled materials "derive models from image and time-series data from the plant to optimize the plant.".

AI is able to be used for processing optimization for waste and also can be used to promote the circular economy. Factories can be maintained mostly by automation and machines enabled with AI. Companies that are focusing on waste management are going to benefit from increased efficiency, increased recycling rates and reduced energy consumption, which is going to have a positive impact on the environment. AI can also be used to optimize image recognition in terms of measurement accuracy and measurement positions, thus also making it a suitable technology. According to Yetilmezsoy et al. (2011), sectors such as steel industries and pharmaceuticals can also greatly benefit from this. AI can also improve our environmental impact via its uses to manage carbon emissions and greenhouse gasses.

AI to Reduce Greenhouse Gas and Carbon Emissions

As mentioned in the Introduction section, climate change is a global concern and is continuing to change our daily lives in terms of the water we drink, the air we breathe and the amount of waste we produce. Carbon and greenhouse gas emissions are significant reasons for climate change which must be addressed as soon as possible.

Greenhouse Gasses

To begin with Greenhouse gasses are primarily called carbon dioxide, methane and nitrous oxide. The problem with these gasses is that they are very difficult to reduce from the atmosphere. Prior to the United Nations Sustainability Goals (UNSGs) requiring everyone, businesses, governments and consumers, to decrease their emissions and reach a global decrease in temperature by at least 1.5 degrees Celsius, worldwide sustainability and emissions control was not particular. Today, we embark on active efforts in our attempts to reach the goal that would contribute to further climate impact on top of the already increased incidents of drought, heat waves, and floods (Stanford, 2022). It was in Paris, in 2015, that almost 200 countries agreed to this temperature decrease in light of our goals.

However, sustainability comes at an increased cost and many nations are struggling to decrease the consumption of fossil fuels and other sources in multiple ways, such as an increase in prices. Consumers and the general global population who like the idea of sustainability seem not to be ready to go fully active and as John Weyant argues, before we create any noticeable change in our climate problem it is necessary "that costs be incurred long before benefits can be realized". Under such circumstances, it is up to our researchers and scientists to help us out

with new technology and methods to remedy the detrimental effects of climate change that humans have created. It is with their help that we will be able to, in the case of energy, "develop materials that store, harvest, and use energy more efficiently", yet the problem remains that this is a slow process of discovery. This is also where artificial intelligence can take centre stage and "Machine learning can accelerate things by finding, designing, and evaluating new chemical structures with the desired properties.". The biggest contributors to greenhouse gas come from the production of cement and steel and it is hoped that new materials could replace them, decreasing emissions by 10%.

In the same vein, AI can also help us manage and reduce our energy consumption thus decreasing our emissions. AI is able to filter data and predict our energy consumption through our habits, such as data that come from "weather forecasts, building occupancy, and other environmental conditions" that could then contribute to the determination of reduced "heating, cooling, ventilation, and lighting needs in an indoor space", for example. The construction of more smart buildings, thus, could also promote direct communication with power sources for management purposes.

Machine learning is a powerful tool that is able to optimize much of our daily life, such as in the optimization of transportation or shipping routes as well as decrease the production of emissions in the production of food, clothing and other industries. But it is also a matter of consumer awareness and cooperation as AI is not able to reduce carbon or greenhouse gas emissions on its own. This is why consumers must "behave in more environmentally aware ways" after they have received "tailored interventions" for their energy-saving goals.

Carbon Emissions

Carbon emissions have primarily been associated with the atmospheric waste of cities. Highly populated urban centres, such as California alone, are where "CO2 and CO are known to be emitted in significant amounts" where the main sources are emissions from fossil fuels that can be created from "biomass burning, fossil fuel combustion (including passenger vehicles...agricultural waste burning, biofuel combustion and industrial processes". In addition, sustainable AI technologies are different kinds of research that apply to the technology of AI and the application of AI by addressing issues of AI sustainability and/or sustainable development. It has been determined that massive clothing brands have great negative effects on the world's water resources, and also it is a fact that technological wastes poison soil that is useful to agriculture. AI seems to be used a lot in both public and private sectors via green technologies and the management of biological ecosystems as well as those constructed by humans such as windmills, hydroelectric dams and many others that work to detect natural disasters and other weather-based issues of interest. Although we still have much to learn about AI, artificial intelligence needs to be known and understood by the masses more in order to protect our world and its people.

Conclusion

In conclusion, climate change without the involvement of artificial intelligence would mean humans would have a difficult time understanding how much waste or carbon emissions they produce, and this would impede our sustainability goals. Without AI to process data and make predictions about our energy-based consumptions and the amount of waste we produce we would have no system of regulation for change. Climate change is not a new problem and it is true that we have AI before our climate change problems, but it seems today that with the advancements made in AI since the 1940s and our urgent climate needs have come together at an important time in our human history. Carbon emissions have become problems that cannot be understood or solved in the absence of artificial intelligence. With the help of AI, it is potentially possible to reduce most of the waste and greenhouse gas emissions without harming the environment.

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